



Projected Costs of U.S. Nuclear Forces, 2019 to 2028

The Congressional Budget Office is required by law to project the 10-year costs of nuclear forces every two years. This report contains CBO's projections for the period from 2019 to 2028.

- If carried out, the plans for nuclear forces delineated in the Department of Defense's (DoD's) and the Department of Energy's (DOE's) fiscal year 2019 budget requests would cost a total of \$494 billion over the 2019–2028 period, for an average of just under \$50 billion a year, CBO estimates.
- The current 10-year total is 23 percent higher than CBO's 2017 estimate of the 10-year costs of nuclear forces, \$400 billion over the 2017–2026 period.
- About \$51 billion (or 55 percent) of the \$94 billion increase in that total arises because the 10-year period covered by the current estimate begins and ends two years later than the period covered by the 2017 estimate. Thus, the period now includes two later (and more expensive) years of development in nuclear modernization programs. Also, costs in those two later years reflect 10 years of economywide inflation relative to the two years that drop out of the previous 10-year projection; that factor (in the absence of any changes to programs) accounts for about one-fourth of the \$51 billion increase.
- About \$37 billion (or 39 percent) of the \$94 billion increase is projected to occur from 2019 to

2026—the eight years included in both this estimate and the 2017 estimate. That increase stems mainly from new modernization programs and weapons and more concrete plans for nuclear command-and-control systems.¹

Background

Nuclear weapons have been an important component of U.S. national security since they were developed during World War II. During the Cold War, nuclear forces were central to U.S. defense policy, and a large arsenal was built. Since that time, nuclear forces have figured less prominently in defense policy than conventional forces have, and the United States has not built any new nuclear weapons or delivery systems for many years.

The nation's current nuclear forces are reaching the end of their service life. Those forces consist of submarines that launch ballistic missiles (SSBNs), land-based intercontinental ballistic missiles (ICBMs), long-range bomber aircraft, shorter-range tactical aircraft carrying bombs, and the nuclear warheads that those delivery systems carry. Over the next two decades, essentially all of those components of nuclear forces will have to be refurbished or replaced with new systems if the United States is to continue fielding those capabilities.

1. The remaining 6 percent of the \$94 billion increase is in CBO's estimate of likely cost growth beyond budgeted amounts.

Notes: Unless this report indicates otherwise, all of the years referred to are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end. Numbers in the text and tables may not add up to totals because of rounding. In this report, “cost” refers to budget authority, the amount that would need to be appropriated to implement the Administration's plans.

In February 2018, the Department of Defense released its *Nuclear Posture Review (NPR)*, a report that laid out the current Administration's plans for nuclear strategy and force structure (see Box 1 on page 4). To a large degree, the report represents a continuation of the nuclear posture of the previous Administration, including continuing all major modernization programs. However, the report also proposes the development of several new nuclear capabilities, which have been the subject of some debate. Over the coming years, the Congress will need to make decisions about what nuclear forces the United States should field in the future and thus about the extent to which the nation will pursue the Administration's nuclear modernization plans.

To help the Congress make such decisions, the National Defense Authorization Act for Fiscal Year 2013 (Public Law 112-239) required CBO to estimate the 10-year costs of operating, maintaining, and modernizing U.S. nuclear forces. In response, CBO published *Projected Costs of U.S. Nuclear Forces, 2014 to 2023*.² Then the National Defense Authorization Act for Fiscal Year 2015 (P.L. 113-291) required CBO to update that estimate every two years. This report is the third such update.³ In addition, in October 2017, CBO published an estimate of the 30-year costs of nuclear forces under existing plans and under various approaches for managing the costs of modernization.⁴

CBO's Projections of the Costs of U.S. Nuclear Forces Through 2028

Over the 2019–2028 period, the plans for nuclear forces specified in DoD's and DOE's 2019 budget requests and in the current *NPR* would cost a total of \$494 billion, CBO estimates (see Table 1). CBO projects that \$432 billion of that total would be needed to implement the Administration's 2019 plans as DoD and DOE have laid them out—provided those plans did not change or experience any cost growth or schedule

delays. The remaining \$62 billion of the 10-year total represents CBO's estimate of additional costs that would be incurred over the 2019–2028 period if the costs of nuclear programs exceeded planned amounts at roughly the same rates at which costs for similar programs have grown in the past.

The \$432 billion would fund the following items:

- **Strategic nuclear delivery systems and weapons (\$234 billion).** This category consists of DoD's funding for strategic nuclear delivery systems (the three types of systems that can deliver long-range nuclear weapons—SSBNs, ICBMs, and long-range bombers), DOE's funding for activities related to the warheads used by those systems, and DOE's funding for the nuclear reactors that power SSBNs.
- **Tactical nuclear delivery systems and weapons (\$15 billion).** This category consists of DoD's funding for tactical aircraft that can deliver nuclear weapons over shorter ranges; DOE's funding for activities related to the warheads that those aircraft carry; funding for a new submarine-launched nuclear cruise missile (SLCM), as called for in the 2018 *NPR*; and funding for a warhead for that missile to carry.
- **DOE's nuclear weapons laboratories and their supporting activities (\$106 billion).** This category consists of funding for activities at nuclear weapons laboratories and production facilities that are not attributable directly to a specific type of warhead but that are related to maintaining current and future stockpiles of nuclear weapons.
- **DoD's command, control, communications, and early-warning systems (\$77 billion).** These systems allow operators to communicate with nuclear forces, issue commands that control their use, detect incoming attacks, and rule out false alarms.

Projected annual budgets for all of those programs together rise steadily from \$33.6 billion to \$53.5 billion over the next decade, CBO estimates, increasing by roughly 60 percent between 2019 and 2028.⁵

2. Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2014 to 2023* (December 2013), www.cbo.gov/publication/44968.

3. The others are Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2017 to 2026* (February 2017), www.cbo.gov/publication/52401, and *Projected Costs of U.S. Nuclear Forces, 2015 to 2024* (January 2015), www.cbo.gov/publication/49870.

4. Congressional Budget Office, *Approaches for Managing the Costs of U.S. Nuclear Forces, 2017 to 2046* (October 2017), www.cbo.gov/publication/53211.

5. For more details about annual costs, see the supplemental data posted with this report on CBO's website at www.cbo.gov/publication/54914.

Table 1.

Projected Costs of Nuclear Forces, by Department and Function

Billions of Dollars

	2019			Total, 2019–2028		
	DoD	DOE	Total	DoD	DOE	Total
CBO's Projections of Budgeted Amounts for Nuclear Forces ^a						
Nuclear delivery systems and weapons						
Strategic nuclear delivery systems and weapons						
Ballistic missile submarines	8.5	1.3	9.8	96	11	107
Intercontinental ballistic missiles	2.6	0.2	2.8	56	5	61
Bombers	3.2	1.2	4.4	38	11	49
Other nuclear activities ^b	1.4	n.a.	1.4	16	n.a.	16
Subtotal	15.8	2.6	18.4	207	27	234
Tactical nuclear delivery systems and weapons	0.2	0.4	0.7	8	8	15
Nuclear weapons laboratories and supporting activities						
Stockpile services	n.a.	2.1	2.1	n.a.	24	24
Facilities and infrastructure	n.a.	3.0	3.0	n.a.	41	41
Other stewardship and support activities ^c	n.a.	3.6	3.6	n.a.	41	41
Subtotal	n.a.	8.7	8.7	n.a.	106	106
Subtotal, Nuclear Delivery Systems and Weapons	16.0	11.8	27.7	214	141	355
Command, control, communications, and early-warning systems						
Command and control	1.4	n.a.	1.4	19	n.a.	19
Communications	2.3	n.a.	2.3	23	n.a.	23
Early warning	2.2	n.a.	2.2	34	n.a.	34
Subtotal, Command, Control, Communications, and Early-Warning Systems	5.8	n.a.	5.8	77	n.a.	77
Total Budgeted Amounts for Nuclear Forces	21.8	11.8	33.6	291	141	432
CBO's Estimates of Additional Costs Based on Historical Cost Growth	n.a.	n.a.	n.a.	35	27	62
Total Estimated Cost of Nuclear Forces	21.8	11.8	33.6	326	168	494

Source: Congressional Budget Office, using data from the Department of Defense and the Department of Energy.

DoD = Department of Defense; DOE = Department of Energy; n.a. = not applicable.

- a. These budgeted amounts do not reflect independent estimates by CBO of the costs of U.S. nuclear forces. Instead, this category is based on CBO's analysis of DoD's and DOE's budget proposals and accompanying documents, as well as on CBO's projections of those budget figures beyond the next five years under the assumption that programs proceed as described in budget documentation. The category also includes several programs for which plans are still being formulated. In those cases, CBO based its estimate on historical costs of analogous programs.
- b. This category includes nuclear-related research and operations support activities by DoD that CBO could not associate with a specific type of delivery system or weapon.
- c. This category includes security forces, transportation of nuclear materials and weapons, and scientific research and high-performance computing to improve understanding of nuclear explosions. This category also includes \$400 million in 2019 and \$5 billion over the 2019–2028 period for federal salaries and expenses.

CBO's projections are not meant to predict DoD's and DOE's future budgets, because Administrations typically change plans from year to year. Rather, the projections serve to extend the cost estimates that underlie the Administration's 2019 budget submission, provided that there are no changes in the planned size and composition

of the nuclear forces or in the type, quantity, and schedule of weapons development programs.

CBO's projections for *individual* programs reflect the assumption that DoD's and DOE's plans will be executed successfully and on budget. In other words, those

Box 1.

The Effects of the 2018 *Nuclear Posture Review* on the Projected Costs of Nuclear Forces

In February 2018, the Department of Defense (DoD) published its *Nuclear Posture Review (NPR)*.¹ Each of the post–Cold War Administrations, beginning with the Clinton Administration, has published such a review to summarize its policies about nuclear weapons and the forces that would be needed to execute those policies. While the current Administration’s *NPR* emphasized the increasing importance of nuclear weapons in a “return to Great Power competition,” the forces that it recommended were largely the same as those recommended by the previous Administration’s *NPR*, which was published in 2010.

However, the 2018 *NPR* called for three increases in nuclear capability that could, if implemented, make the costs of nuclear forces about \$17 billion higher over the next 10 years than they would have been otherwise (although that estimate is very uncertain). The three increases are a nuclear warhead with relatively low explosive yield to be carried on submarine-launched ballistic missiles; a new sea-launched nuclear cruise missile (SLCM); and an increase in U.S. capacity to produce plutonium pits.² Those capabilities would affect the costs of nuclear forces to varying degrees.

1. Department of Defense, *Nuclear Posture Review* (February 2018), <https://go.usa.gov/xEcng>.
2. A pit is a hollow shell of fissile material, such as plutonium, at the core of a modern nuclear weapon. Detonation of the weapon begins with the implosion of the pit.

A New Nuclear Warhead for Submarine-Launched Missiles

To implement the first of those new capabilities, the Department of Energy (DOE) would produce a small number of low-yield versions of the W76 warhead, designated the W76-2, for deployment on submarine-launched ballistic missiles. It would cost \$65 million for DOE to develop and produce that capability and about \$50 million for DoD to make the changes necessary to use it on its submarines, according to the two departments.

A New Sea-Launched Nuclear Cruise Missile

To implement the *NPR*’s call for a new SLCM, DoD will analyze alternatives to determine how best to proceed. Because the plans are still being formulated, there is a great deal of uncertainty about the cost of fielding that capability. However, the *NPR* also called for reducing costs by taking advantage of existing technologies and capabilities. For this estimate, the Congressional Budget Office assumed that the new SLCM would draw heavily from the design of the Long-Range Standoff Weapon (LRSO)—a new nuclear cruise missile that the Air Force is developing for bomber aircraft—and its warhead. Using that approach, CBO assumed that the SLCM’s total development costs would be 50 percent less than the LRSO’s and that unit production costs would be the same. CBO’s estimate includes about \$9 billion from 2019 to 2028 for the new SLCM and its warhead, although that estimate is very uncertain. That total does not include any costs for production after 2028 (if

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projections are based on the Administration’s estimates and do not incorporate any cost growth beyond the funding levels planned by the two departments or any schedule delays. However, because programs often cost more than originally planned, CBO has incorporated cost growth into its *overall* estimate of the costs of nuclear forces. Overall, CBO estimates a total of \$62 billion in cost growth beyond budgeted amounts over the 10-year period. When that cost growth is included, estimated annual costs rise from \$33.6 billion in 2019 to about \$63 billion in 2028, an increase of roughly 90 percent over that period.⁶

6. For 2019, the first year of the estimate, CBO’s model includes no cost growth beyond budgeted amounts.

Nuclear forces account for roughly 6 percent of the total 10-year cost of the plans for national defense outlined in the President’s 2019 budget submission, CBO estimates.⁷ On an annual basis, that percentage is projected to rise from about 5 percent in 2019 to about 7 percent in 2028. Those percentages are roughly the same as the ones that CBO estimated for the 2017–2026 period: Although the 10-year costs of nuclear forces are higher in this estimate than in the previous estimate, the total estimated costs of national defense have also increased at about the same rate.

7. That estimate is based on CBO’s analysis of information in Department of Defense, Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for FY 2019* (April 2018), p. 18, Table 1-11, <https://go.usa.gov/xEDVX> (PDF, 8.1 MB).

Box 1.

Continued

The Effects of the 2018 *Nuclear Posture Review* on the Projected Costs of Nuclear Forces

necessary), integrating the SLCM onto submarines or surface ships, or any associated operations or security costs.

Expanded Capacity to Produce Plutonium Pits

To implement the third increase in capability called for in the *NPR*, DOE plans to boost its production capacity so that it can produce at least 80 plutonium pits per year by 2030; previous plans called for the capacity to produce 50 to 80 pits. DOE plans to expand its existing and planned production facilities at Los Alamos, New Mexico, and also to begin production at a second site by adapting a partially built facility at Savannah River, South Carolina, that had been originally intended for another purpose. CBO's estimate includes about \$9 billion from 2019 to 2028 for expanded pit production capacity, although that estimate is very uncertain.

Other Policies in the *NPR*

In addition, the 2018 *NPR* made several policy statements that could make nuclear forces cost more than CBO has estimated in this report. First, the *NPR* said that the B83 nuclear bomb, which previously had been scheduled to be retired, would instead be retained until a "suitable replacement" was identified. The B83, the last U.S. nuclear weapon with an explosive yield of more than a megaton, is the most powerful weapon in the arsenal.³ The *NPR* is not specific about the nature of a

suitable replacement. But if the Administration determines that a new nuclear weapon is needed or that the B83 requires a life-extension program, new costs would be incurred, probably within the next 10 years and also later.

Second, the *NPR* stated that the United States would develop a ground-launched intermediate-range ballistic missile that does not carry a nuclear weapon in response to Russia's violation of the terms of the Intermediate-Range Nuclear Forces treaty. (That treaty allows ground-launched intermediate-range missiles for both nuclear and conventional missions to be developed but not flight-tested or deployed.) However, after the *NPR* was released, the Administration announced its intention to withdraw from the treaty. The Administration has not indicated that it will develop a new nuclear-capable ballistic missile after withdrawing from the treaty, but if it decided to build such a weapon, that decision would lead to additional costs for nuclear activities, potentially within the next 10 years and later as well.

Finally, the *NPR* indicated that DoD would build a minimum of 12 new nuclear ballistic missile submarines, whereas earlier plans had called for ending construction at 12. If more than 12 submarines are built, costs for nuclear activities will increase in the long run but not within the next 10 years (because the 12th submarine is not slated to be authorized until 2035).

3. A megaton is equivalent to 1 million tons (2 billion pounds) of TNT.

Basis of CBO's Updated Estimates

CBO's total estimate in this report consists of the costs of fielding, operating, maintaining, and modernizing U.S. nuclear forces. CBO prepared the report using the same approach that it used in its original 2013 report, considering only costs that the agency identified as directly associated with the nuclear mission.⁸ Unlike estimates by some other analysts, CBO's estimate does not include a prorated share of the military services' and DoD's overhead and support costs that are not specific to the nuclear mission—although such costs could change if DoD made significant changes in the size of its nuclear forces.

8. For more details about nuclear programs and CBO's approach to estimating costs, see Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2014 to 2023* (December 2013), www.cbo.gov/publication/44968.

Besides the costs directly attributable to fielding nuclear forces, some published estimates of the total costs of nuclear weapons account for the costs of several related activities. Examples include the costs of addressing the nuclear legacy of the Cold War (such as dismantling retired nuclear weapons and cleaning up environmental contamination from past activities at nuclear facilities); the costs of reducing the threat from other countries' nuclear weapons (including U.S. efforts to halt proliferation, comply with arms control treaties, and verify other countries' compliance with treaties); and the costs of developing and maintaining active defenses against other countries' nuclear weapons (primarily ballistic missiles). CBO has not updated its estimate of those costs, which was published in 2013, and such costs are not included in this report.

For this update, CBO analyzed DoD's and DOE's 2019 budget requests and their associated justification documents, which include the amounts that they have planned for the next five years. To produce 10-year estimates, CBO identified the budget lines for programs related to nuclear forces and extended them beyond the five-year period by examining the departments' long-range plans for each program. For replacement systems that are in the early stages of development during the 2019–2028 period but that are not yet fully reflected in the departments' budgets (such as a new ICBM and a new cruise missile), CBO estimated costs by reviewing the actual costs for analogous systems that have already been built and the schedules that would be necessary to produce systems as promptly as needed to maintain inventories at the levels planned in the 2019 budget requests. The methods used to perform most of those estimates of costs are the same ones that CBO used in its earlier estimate of the 30-year costs of nuclear forces and are described in detail in that report.⁹

For programs that have been introduced since that document was published, CBO took the same general approach, using historical analogues on which to base estimated costs. In particular, CBO assumed that DoD would field a new SLCM as directed in the *NPR* and that the design would draw from the development of a different missile—a new air-launched cruise missile called the Long-Range Standoff Weapon and referred to as the LRSO—and its associated warhead. Specifically, CBO assumed that development costs for the SLCM would be half of the estimated total development costs of the LRSO and that the unit production costs of the two weapons would be the same. In the same way, CBO assumed that the SLCM's warhead would be similar to the LRSO's W80-4 warhead and projected that it would cost half as much to develop and have the same unit production costs. Overall, CBO's estimate of the costs of the SLCM and its warhead—about \$9 billion over the period from 2019 to 2028—is highly uncertain; in fact, it is still not clear whether the program will be pursued at all, and if so, what the design and development schedule will be. CBO did not include in its estimates any costs of integrating the SLCM onto submarines or surface ships; most of those costs would presumably occur after 2028.

9. See Congressional Budget Office, *Approaches for Managing the Costs of U.S. Nuclear Forces, 2017 to 2046* (October 2017), Appendix A, www.cbo.gov/publication/53211.

CBO's estimate of the costs of another new program, the replacement of the engines on the B-52 bomber aircraft, is based on the actual costs of replacing aircraft engines in the past as well as on statements by the Air Force. The costs of that effort over the 2019–2028 period contribute about \$1 billion to CBO's estimate of the total costs of nuclear forces.¹⁰

To project personnel costs and the costs of operation and maintenance activities from 2024 to 2028, CBO began with the levels of operation and maintenance activities and the number of military personnel planned for 2023 and projected that those levels would remain the same for the last five years of the period. CBO projects that the cost to maintain those levels will grow slightly faster than inflation, a projection that is based on DoD's past experience.

To arrive at an estimate of overall cost growth, CBO used two different approaches. For some major modernization programs, CBO used the cost estimates that it developed as part of its 2017 estimate of the 30-year costs of nuclear forces to estimate how much costs might rise above DoD's current projected budgets for those programs.¹¹ For all other programs and activities, CBO estimated cost growth for the four categories of costs (research and development, procurement, military personnel, and operation and maintenance) as a whole, rather than program by program, on the basis of experience with DoD's and DOE's programs.¹²

Changes in Estimated Costs

The estimate of \$494 billion in total costs for nuclear forces over the 2019–2028 period is \$94 billion, or 23 percent, more than CBO's February 2017 estimate of

10. Bombers are used both for nuclear and for conventional missions. In these 10-year estimates, CBO attributes 25 percent of the costs of the B-52 bomber and the new B-21 bomber to the nuclear mission and 75 percent to the conventional mission. Therefore, only 25 percent of the cost of replacing the engines on the B-52 (which CBO estimates would total \$6 billion through 2028) is included in this estimate.

11. For details about those estimates, see Congressional Budget Office, *Approaches for Managing the Costs of U.S. Nuclear Forces, 2017 to 2046* (October 2017), Appendix A, www.cbo.gov/publication/53211.

12. For more details about CBO's approach to estimating cost growth, see Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2014 to 2023* (December 2013), p. 18, www.cbo.gov/publication/44968.

Table 2.

Differences in 10-Year Costs Between CBO's Current and Previous Projections of the Costs of Nuclear Forces

Billions of Dollars

	10-Year Costs		
	DoD	DOE	Total
CBO's Previous Projection			
Total Estimated Costs, 2017 to 2026	267	134	400
Difference in 10-Year Total (Current projection minus previous projection)^a			
CBO's Projections of Budgeted Amounts for Nuclear Forces ^b			
Nuclear delivery systems and weapons			
Ballistic missile submarines	16	1	17
Intercontinental ballistic missiles	16	2	18
Bombers	4	2	6
Other DoD nuclear activities ^c	3	n.a.	3
Tactical nuclear delivery systems and weapons	1	5	6
Nuclear weapons laboratories and supporting activities	n.a.	19	19
Command, control, communications, and early-warning systems	19	n.a.	19
Subtotal, CBO's Projections of Budgeted Amounts for Nuclear Forces	59	29	88
CBO's Estimates of Additional Costs Based on Historical Cost Growth	*	5	6
Total Difference	59	34	94
CBO's Current Projection			
Total Estimated Costs, 2019 to 2028	326	168	494

Source: Congressional Budget Office, using data from the Department of Defense and the Department of Energy.

DoD = Department of Defense; DOE = Department of Energy; n.a. = not applicable; * = less than \$500 million.

- a. A positive amount indicates that the current projection is greater than the previous one, which was published in Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2017 to 2026* (February 2017), www.cbo.gov/publication/52401.
- b. These budgeted amounts do not reflect independent estimates by CBO of the costs of U.S. nuclear forces. Instead, this category is based on CBO's analysis of DoD's and DOE's budget proposals and accompanying documents, as well as on CBO's projections of those budget figures beyond the next five years under the assumption that programs proceed as described in budget documentation. The category also includes several programs for which plans are still being formulated. In those cases, CBO based its estimate on historical costs of analogous programs.
- c. This category includes nuclear-related research and operations support activities by DoD that CBO could not associate with a specific type of delivery system or weapon.

\$400 billion over the 2017–2026 period (see Table 2). The percentage increases are similar for DoD and DOE: DoD's costs are projected to total \$326 billion, or 22 percent more than the \$267 billion that CBO estimated in 2017, and DOE's costs are projected to total \$168 billion, or 25 percent more than the \$134 billion that CBO estimated in 2017.

The higher estimates in this report do not all signal an increase in programs' total lifetime costs. For example, about 55 percent (or \$51 billion) of the \$94 billion

difference between CBO's current and 2017 estimates occurs because the current projections cover a 10-year period that starts and ends two years later than the period covered by the 2017 estimate. Therefore, in the latest estimate, new programs are two years further along in the process of ramping up development, and some are entering the production phase—both of which tend to be characterized by higher annual costs. Also, costs in those two later years reflect 10 years of economywide inflation relative to the two years that drop out of the 10-year projection; that factor (in the absence of any

changes to programs) accounts for about one-fourth of the \$51 billion increase.

An additional 39 percent (or about \$37 billion) of the difference between CBO's current and previous projections involves the eight years in which the projections overlap (see Box 2). Differences in estimates for those years stem from a number of factors:

- Some modernization plans, particularly for new command-and-control aircraft and for satellite systems that support nuclear forces, have become better defined since 2017, leading to higher estimates;
- Some new modernization efforts have been introduced, including installing new engines on B-52 bombers and developing a new reentry vehicle for the new ICBM being produced in the Ground-Based Strategic Deterrent (GBSD) program; and
- Some new weapons and support capabilities, specifically an increased capacity for DoE to produce plutonium pits, were introduced in the 2018 *NPR* (see Box 1 on page 4).¹³

The remaining 6 percent (or about \$6 billion) of the \$94 billion increase in CBO's 10-year projections occurs in CBO's estimate of likely cost growth beyond budgeted amounts. The estimate of cost growth applies to the full 10-year period, and the difference between the current and previous estimates cannot reliably be divided between the overlapping and nonoverlapping years.

The largest contributions to the \$94 billion increase are higher costs for nuclear delivery systems and weapons, including costs for weapons laboratories and supporting activities. Projected costs for command, control, communications, and early-warning systems have also increased substantially. And CBO's projection of cost growth over 10 years is somewhat higher than it was in 2017.

13. A pit is a hollow shell of fissile material, such as plutonium, at the core of a modern nuclear weapon. Detonation of the weapon begins with the implosion of the pit. Like producing several other components of a nuclear weapon, producing pits entails extensive processing of very hazardous material, which typically requires a specialized facility. The various components are then collected and assembled into a complete nuclear weapon in a separate facility dedicated to that purpose.

Nuclear Delivery Systems and Weapons

By CBO's estimate, the amounts needed to implement the Administration's 2019 plans for nuclear systems and weapons (provided those plans did not change or experience any cost growth or schedule delays) would total \$355 billion over 10 years, \$69 billion more than the \$286 billion that CBO estimated in 2017. The main reason for that rise is that modernization plans are further along in development. In addition, plans for some programs have become clearer or have changed since the departments' budget requests for 2017.

Ballistic Missile Submarines. Budgeted amounts for SSBNs would total \$107 billion over 10 years, CBO projects. That total is about \$17 billion more than the 2017 estimate (see Table 2). Most of that amount would be for DoD's SSBN programs, which are projected to cost \$96 billion over the next decade, about \$16 billion more than CBO's 2017 estimate.

Almost all of the increase results from the fact that the current estimate extends through 2028 rather than 2026. Under the plans in DoD's 2019 budget request, the program for developing a new SSBN will have completed the design phase and be nearing the halfway point of production by 2028. In that year, the fifth new submarine (of 12 total) is expected to be authorized, and the four submarines that had been authorized previously would be under construction. The program would then be entering a plateau in the construction effort that would extend for nearly a decade after 2028; whereas authorization of the first two submarines would be spread over five years, plans call for a new one to be authorized every year from 2026 through 2035. Another high-profile, although fairly low-cost, effort is outfitting SSBNs with a nuclear warhead with a relatively low explosive yield.¹⁴ That effort is expected to result in about \$50 million in new costs for the Navy to implement the capability aboard the submarines.

DOE's share of the amounts budgeted for SSBNs would be \$11 billion over 10 years, CBO projects, \$1 billion more than the 2017 estimate. That net increase results

14. The precise yield of the new warhead has not been specified. However, low-yield nuclear warheads carried by U.S. bomber aircraft have explosive yields as low as 0.3 kilotons, according to unclassified sources, which is equivalent to 600,000 pounds of dynamite. The nuclear warheads currently carried on SSBNs have 100-kiloton and 450-kiloton explosive yields, according to unclassified sources.

from offsetting factors: Some efforts (specifically, life-extension programs for the W76 and W88 warheads) are projected to finish, pushing the estimate of total costs down, whereas the costs of others are increasing as programs begin or move further into development (such as programs to develop interoperable warheads called IW-1 and IW-2).¹⁵ The new effort to produce a warhead with a relatively low explosive yield for SSBNs would add about \$65 million to DOE's SSBN-related costs, according to DOE's statements.

Intercontinental Ballistic Missiles. The amounts budgeted for ICBMs would total \$61 billion over 10 years, CBO projects, about \$18 billion more than the 2017 estimate. Of that total, about \$56 billion would go to DoD and about \$5 billion would go to DOE.

Most of the increase in DoD's share of the costs results from a ramp-up in the costs of development and early production of a new ICBM, the missile portion of the GBSD program. When making this estimate, CBO assumed that production would begin in 2026 and continue into the 2030s. The increase in this estimate of the costs of the GBSD missile is mostly the result of the time period's starting and ending two years later than the period used for the 2017 estimate. Similarly, the ramp-up of an effort to refurbish the ICBM silos and communications infrastructure has contributed to an increase in DoD's projected ICBM costs over 10 years. However, some of the increase in this category is the result of an increase in DoD's estimate for the total development cost of the GBSD program. Other major contributors to the increase are a new program to develop a reentry vehicle to house the nuclear warheads on the GBSD and higher projected operating costs for the Minuteman III (the current-generation ICBM).

DOE's ICBM costs are projected to be about \$2 billion higher over the next 10 years than CBO estimated in 2017. The main reason is that two more years of the programs to develop the IW-1 and IW-2 interoperable warheads occur within the 10-year estimation period.

Bombers. Under the plans in the departments' 2019 budget request, the amounts budgeted for the bomber portion of nuclear forces would total \$49 billion over 10 years, CBO projects, about \$6 billion more than CBO's 2017 estimate. Of that total, \$38 billion would go to DoD (\$4 billion more than CBO estimated in 2017), and \$11 billion would go to DOE (\$2 billion more than CBO estimated in 2017).¹⁶

The increase in DoD's costs in this area reflects a combination of several effects. CBO's current estimate includes two more years of production for the LRSO cruise missile and the B-21 bomber than the 2017 estimate did (production is slated to begin in the mid-2020s for both systems). Also, the current estimate accounts for a new modernization program that will replace the engines on B-52 bombers and for increases in the cost of sustaining B-52 bombers and the current-generation nuclear cruise missile. Those increases are partially offset by a decrease in the cost of sustaining B-2 bombers; in 2018, the Air Force announced that it would retire the B-2 fleet in the early 2030s, about 20 years earlier than previously planned. On the DOE side, most of the increase in costs is for extending the life of the W80-4 warhead, both because that effort is now two years further along and because DOE has increased its estimate of the program's overall cost.

Other DoD Nuclear Activities. This category, which includes various DoD support activities for strategic nuclear forces that CBO was not able to associate with a particular weapon system, would total \$16 billion over 10 years, about \$3 billion more than CBO's 2017 estimate. That increase is mostly for a new Air Force program, called Acquisition Workforce–Nuclear Systems, which realigns costs for program management and related support from the programs for individual weapon systems to a combined effort in order to allow those support costs to be tracked more directly. The apparent increase therefore represents a recategorization of costs rather than an overall increase.

15. Interoperable warheads will incorporate a novel approach that will allow them to be used on both ground-based and submarine-based ballistic missiles. In the *NPR* and some recent DOE documents, however, the IW-1 is referred to as the "W78 replacement" (the W78 is a warhead for ICBMs), and its potential use on SSBNs is described as a subject for research. For this estimate, CBO has continued to split IW-1 costs evenly between the ICBM and SSBN categories, as it did in previous analyses.

16. Bombers are used both for nuclear and for conventional missions. In these 10-year estimates, CBO attributes 25 percent of the costs of the B-52 bomber and the new B-21 bomber to the nuclear mission and 75 percent to the conventional mission. For the B-2 bomber and nuclear-capable cruise missiles, by contrast, CBO attributes all costs to nuclear missions. If the full cost of B-52 and B-21 bombers was included, the costs of bombers would total \$104 billion over 10 years, and the total costs of nuclear forces would be \$559 billion.

Box 2.

Differences Between CBO's Current and Previous Estimates During Years of Overlap

One of the goals of updating this report every two years is to assess the budgetary effects of changes in plans for nuclear forces, or in the execution of those plans, since the previous report was published. The most direct method of doing that is to compare estimates only during the eight years in which the two reports overlap (see the table). That approach highlights

differences between estimates that are the result of changes in plans by largely removing the effects of the natural ramp-up of activity typical of weapons development programs and the effects of economywide inflation in prices. Unless they are offset by cost reductions after 2028, the changes in plans are likely to increase the long-term costs of nuclear forces.

**Differences in 8-Year Costs Between CBO's Current and Previous Projections of the Costs of Nuclear Forces
(During the overlapping years, 2019–2026)**

Billions of Dollars

	8-Year Costs		
	DoD	DOE	Total
CBO's Previous Projection			
Total Estimated Costs, 2019 to 2026 ^a	196	92	288
Difference in 8-Year Total (Current projection minus previous projection)^b			
CBO's Projections of Budgeted Amounts for Nuclear Forces ^c			
Nuclear delivery systems and weapons			
Ballistic missile submarines	1	1	2
Intercontinental ballistic missiles	4	0	4
Bombers	1	2	2
Other DoD nuclear activities ^d	2	n.a.	2
Tactical nuclear delivery systems and weapons	0	4	4
Nuclear weapons laboratories and supporting activities	n.a.	10	10
Command, control, communications, and early-warning systems	11	n.a.	11
Total Difference	19	18	37
CBO's Current Projection			
Total Estimated Costs, 2019 to 2026 ^a	215	110	325

Source: Congressional Budget Office, using data from the Department of Defense and the Department of Energy.

This table does not include CBO's estimate of cost growth beyond budgeted amounts. The estimate of cost growth applies to the full 10-year period, and the difference between the current and previous estimates cannot reliably be divided into the overlapping and nonoverlapping years.

DoD = Department of Defense; DOE = Department of Energy; n.a. = not applicable.

a. Total does not include additional costs based on historical cost growth.

b. A positive amount indicates that the current projection is greater than the previous one, which was published in Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces, 2017 to 2026* (February 2017), www.cbo.gov/publication/52401.

c. These budgeted amounts do not reflect independent estimates by CBO of the costs of U.S. nuclear forces. Instead, this category is based on CBO's analysis of DoD's and DOE's budget proposals and accompanying documents, as well as on CBO's projections of those budget figures beyond the next five years under the assumption that programs proceed as described in budget documentation. The category also includes several programs for which plans are still being formulated. In those cases, CBO based its estimate on historical costs of analogous programs.

d. This category includes nuclear-related research and operations support activities by DoD that CBO could not associate with a specific type of delivery system or weapon.

Box 2.

Continued

Differences Between CBO's Current and Previous Estimates During Years of Overlap

The cost categories with the largest differences in projected budgets during the overlapping years (excluding cost growth beyond budgeted amounts) are command, control, communications, and early-warning systems of the Department of Defense (an \$11 billion increase) and nuclear weapons laboratories and supporting activities of the Department of Energy

(a \$10 billion increase). There are smaller increases in the categories for tactical weapons and intercontinental ballistic missiles. The changes in programs that led to those increases in the Congressional Budget Office's estimates are described elsewhere in this report.

Tactical Nuclear Delivery Systems and Weapons. CBO estimates that tactical nuclear capability would cost \$15 billion over the next 10 years, about \$6 billion more than CBO's 2017 estimate. That \$15 billion total would be almost evenly split between DoD and DOE. The increase is almost all the result of the projected development and fielding costs of the new sea-launched nuclear cruise missile that was called for in the 2018 *NPR*. The technical specifications of that missile, and whether it will be carried on surface ships, submarines, or both, are under review. For the purpose of this estimate, CBO assumed that the new cruise missile and its warhead would be derived from ongoing development of the LRSO.

Nuclear Weapons Laboratories and Supporting Activities. The amounts that DOE budgets for its nuclear weapons laboratories and supporting activities would total \$106 billion over 10 years, CBO projects, \$19 billion more than the 2017 estimate. Nearly all components of the laboratories' costs have increased in relation to the previous estimate. One large contributor to the increase is that DOE has made its plans for plutonium pit production clearer. In the 2018 *NPR*, the Administration stated a goal of producing at least 80 pits per year by 2030, an increase over the goals stated in the previous plan (see Box 1 on page 4). Also increasing projected costs are an effort to catch up on deferred maintenance at DOE facilities (many of which date to the original nuclear weapons development effort in World War II) and increased production of strategic materials.¹⁷

Command, Control, Communications, and Early-Warning Systems

The amounts that DoD budgets for nuclear command, control, communications, and early-warning systems would total \$77 billion over 10 years, CBO projects, about \$19 billion more than the 2017 estimate. That increase is driven largely by changes to modernization programs, specifically the development and purchase of a new fleet to replace the National Airborne Operations Center (NAOC) aircraft and new concepts for early-warning satellites and communications satellites used by nuclear forces. For the NAOC program, DoD's 2019 budget calls for combining plans for NAOC aircraft with plans for other nuclear command-and-control aircraft and producing a single fleet of similar aircraft, called Survivable Airborne Operations Center aircraft; that approach would produce more new aircraft than were included in CBO's 2017 estimate. For the satellite programs, DoD plans to replace the Space-Based Infrared System, which detects missile launches by adversaries, with the Next-Generation Overhead Persistent Infrared system, along with a new ground system for communicating with those satellites. In addition, DoD intends to replace the Advanced Extremely High Frequency communications satellites, which allow communication among nuclear forces, with new satellites called Evolved Strategic SATCOM.¹⁸ For all of those programs, plans are still being formulated, so there is substantial uncertainty in CBO's cost estimates.

17. Such materials include uranium, plutonium, tritium, and lithium.

18. DoD's plan for the evolution of satellite communications using protected frequencies will also include satellites and services to communicate with conventional forces; the costs of those systems are not included in this estimate.

Additional Costs Based on Historical Cost Growth

Weapons programs frequently cost more than originally budgeted. If nuclear programs exceeded planned amounts at roughly the same rates that costs for similar programs have grown in the past, they would cost an additional \$62 billion over the next 10 years, \$6 billion more than the cost growth that CBO estimated in 2017. Nearly all of that increase is in DOE's share of the costs of nuclear forces, mainly because DOE's plans include increased efforts to extend the service lives of warheads and to build new facilities. Historically, those types of efforts have been particularly susceptible to cost growth.

This Congressional Budget Office report was prepared in response to a requirement in the National Defense Authorization Act for Fiscal Year 2015. Previous editions are available at <https://go.usa.gov/xEbKJ>. In keeping with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

Michael Bennett prepared the report with guidance from David Mosher. Raymond Hall collaborated on the cost estimates in the report with guidance from David Newman. Carla Tighe Murray fact-checked the report.

Jeffrey Kling and Robert Sunshine reviewed the report. Benjamin Plotinsky edited it, and Jorge Salazar prepared it for publication. An electronic version is available on CBO's website (www.cbo.gov/publication/54914).

CBO continually seeks feedback to make its work as useful as possible. Please send any feedback to communications@cbo.gov.



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